International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 9, Issue 3, Jun 2019, 879-886

THE DESIGN AND ANALYSIS OF CABLE DRIVEN PARALLEL MANIPULATOR FOR LOWER LIMB REHABILITATION

Dr. G. YEDUKONDALU[1], Y. TARUN[2], A. SURYA PAVAN[2], B. SAI VINAY[2] & P. MANOJ[2]

[1]*Associate Professor, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Andhra Pradesh, India*

[2]*Student, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Andhra Pradesh, India*

ABSTRACT

The improvement of mechanical gadgets to use among the restoration procedure of human lower appendages is supported by the expansive vary of individuals with lower appendage issues due to strokes or mischances. consequently, throughout this task we've got a bent to gift a link driven parallel controller for lower appendage recovery that's created by a settled base and a movable stage that will be associated with one link at the foremost six and may enjoying out the event of human GAIT and conjointly the individual developments of the hip, the knee and conjointly the lower leg. The task begins with an associate investigation of the essential developments of the lower appendage. At that point the kinetostatic and power examination were introduced. The graphical reproduction and trial of the link driven parallel structure for lower appendage recovery developments are displayed demonstrating the suitability of the projected structure. Structure and examination is finalised by the CATIA and ANSYS.

KEYWORDS: GAIT, Lower Limb & Rehabilitation

Received: Mar 27, 2019; **Accepted**: Apr 17, 2019; **Published**: May 17, 2019; **Paper Id.**: IJMPERDJUN201996

Original Article

1. INTRODUCTION

The folks political economy information free by the international organisation [Statistics Division 2016] assessments that within the year 2016, 16.2% of the lots (i. e. 119 Million) was over sixty five years or recent. The folks developing measures [Population Division 2009] note that the dimension of lots developed sixty years or additional ready can increase from twenty two in 2009 to thirty four in 2050. The position support extent, delineate as "Number of people developed fifteen to sixty four years for every individual developed sixty five or over" can scale back from four out of two009 to 2 out of 2050. we have a tendency to are so looked with a development within the typical age of the folks. An older individual is slanted to diseases and impediment that need the openness of a parental figure. A larger developed folks raises the probability of a requirement for additional watchmen. The folks checks' purpose to an insufficiency within the quantity of sound, additional energetic parental figures and a move within the real prosperity connected problems. we have a tendency to are in and of itself looked with 2 endeavours: analyse and create characteristic philosophy and answers for problems that, within the progressing future, an extending larger piece of the lots can encounter the evil impacts of; create developments that alter an older and incapacitated individual to securely accomplish an plenty of step by step errands overtly.

An obvious issue that the older face could be a diminished ability. They get on my feet to problems in step by step, standard activities like walking, ascent stairs and even an immediate distinction in position. A champion

among the foremost unremarkably compact joints is that the knee. AN adversity in helpfulness of the knees astonishingly impacts ability. Knee degenerative arthritis (OA) could be a primary drain that impacts the older, with a standard 25-30% of these stricken by OA within the ages 45-64 and sixtieth additional ready than sixty five. Comparable examinations raise that a standard ninth of men and eighteenth of girls developed in more than sixty five encounter the evil impacts of OA. OA within the knee impacts the sinew, sporting it away and pain the neighbouring bones. Whereas OA is not the principle condition that impacts the knee, its transcendence among the developed create it a basic issue to revolve around. In any case, the beginning of ginglymoid joint degeneration happens even among the energetic and sound. Amusement wounds provoke patellofemoral torment (PFP) that is said to sesamoid bone arrangement and flaky sesamoid bone when [Lin et al. 2003]. Chondromalacia could be a much identical issue caused by hurt, misuse or sesamoid bone arrangement that impacts the articulacy sinew of the kneecap (patella). It as often as conceivable impacts sprinters and shields the kneecap from skimming over the thigh-bone, pain the sinew. Unnatural rotate of the knee whereas bearing weight will hurt the menisci, creating the knee snap, jolt or perhaps divulge. symmetrical ligaments are equally compact by abrupt knee turns, that happen oftentimes in diversions [NIAMS]. Front symmetrical ligament (ACL) wounds are extraordinarily transcendent among sportsmen.

Despite whether or not these injuries are often recognized and treated, conceded treatment might incite degeneration of the knee. ACL has been identified to construct the occasion of knee OA [Gelber et al. 2000; Von Porat et al. 2006]. As noted in [Von Porat et al. 2006], subjects with ACL wounds have a modified walk arrange. Thusly, a chronic condition may be recognized applicable on time by look stride structures [Li et al. 2005] and preventive medicine may be dead to delay the real effects of loss of skilfulness. Dismembering human advance offers an additional conspicuous appreciation of the mechanics of walking, the result of individual qualities on walk plans, and therefore the occasion and growth of hurt. It's what is more empowers the USA to know the activity of rehabilitative exercises in recovery and helps ameliorating the plans for prostheses.

2. DESIGN OF THE PARALLEL MANIPULATOR

This project consists of 4 motors, table, pulley, Wheel chair and patient. We have to fix the motor according to our specifications and required power and torque to be produced for lifting of the patient’s leg these motors are controlled by the AURDINO or C-Language Code or MATLAB Commands [11-12]. The main task ahead of us is for the selection of the Stepper Motor there are several motors available for the same processes but we need to select the motor based upon the Torque and power produced from the motor which must be able to rotate the winch and able to sustain the capacity of the weight of the patient’s leg.

2.1 Selection of the Motor

Stepper motors are DC motors that move in discrete advances. They have numerous loops that are sorted out in gatherings called "stages". By stimulating each stage in succession, the motor will pivot, with extra special care. For considering a motor, the following qualities are necessary they are: Positioning, Low speed torque and speed control Based on the above qualifications we are searching for a motor capable of producing torque and power the stepper motor we have decided is the NEMA 34 whose specifications are given below. We also need to consider the dimensions of the motor in minimum such that we are able to connect to the table.

Table1: Specifications of Motor

Specifications

6.3 Amp motors		Single length	Double length	Triple length
Part number		M-3424-6.3 • *(1)*	M-3431-6.3 • *(1)*	M-3447-6.3 • *(1)*
Holding torque	oz-in	419	637	1203
	N-cm	296	450	920
Detent torque	oz-in	10.9	14.2	19.8
	N-cm	7.7	10.0	14.0
Rotor inertia	oz-in-sec²	0.01416	0.02266	0.04815
	kg-cm²	1.0	1.6	3.4
Weight	oz	60.0	84.7	141.1
	grams	1700	2400	4000
Phase current	amps	6.3	6.3	6.3
Phase resistance	ohms	0.25	0.35	0.50
Phase inductance	mH	1.6	3.3	6.6

(1) Indicate S for single-shaft or D for double-shaft. Example M-3424-6.3S

A 100*100mm square mount with 1.6mm thickness with minimum thickness which can resist the shear stress produced by the weight of itself and the force with which the winch rotates. It is also attached with a bracket at its bottom such that the pulley can be attached to it.

3. POSITIONING OF THE BRACKET

The center bracket of 100*100 mm^2 is flexible enough such that the mount is able to move freely in all three possible directions. but the amount of freedom in which the axis can be moved is restricted due to the angle of ankle, knee joint and hip joint. This is the important part where the signals need to be given to the stepper motor to give the free moment of the leg which is foreseen by a supervisor. We need to give the exact positions based on all the axis and coordinates too. For the coordinates to be given we have a formula which relates the angle of rotation and position of the center axis. The ankle can freely rotate in all three axes and below table gives a brief view of the angles that it can rotate.

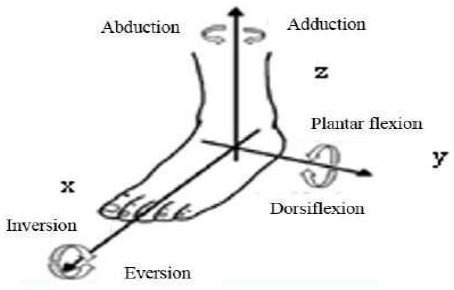

Figure 1: The Diagram of Ankle with Axis

Table 2: Angle of Rotation and Flexibility

Axes	Name of the Motion	Range of Motion
X	Eversion	10° - 17°
	Inversion	14.5° - 22°
Y	Plantar flexion	37° - 45°
	Dorsiflexion	20° - 30°
Z	Abduction	15° - 25°
	Adduction	22° - 35°

As likely the knee and hip joint has also some angular limits the knee joint has a limit of 0-135 degrees. The hip joint has the limit of -18 – 113degrees. These pictures given below must give you a clear-cut idea.

The forces that are being exerted on the patients' legs are very small and the body will be able to overcome them, but the problem is with the direction and degree of freedom with the rotation of the leg i. e (The ankle joint hip and the knee joint).

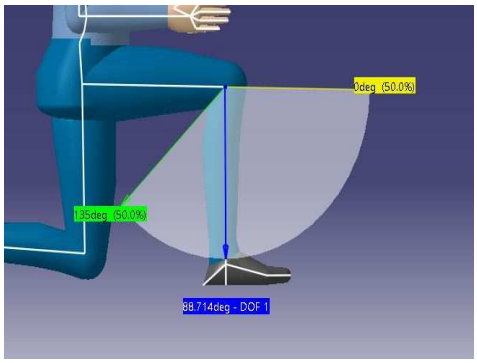

Figure 2: Limits of Angles of Knee Joint

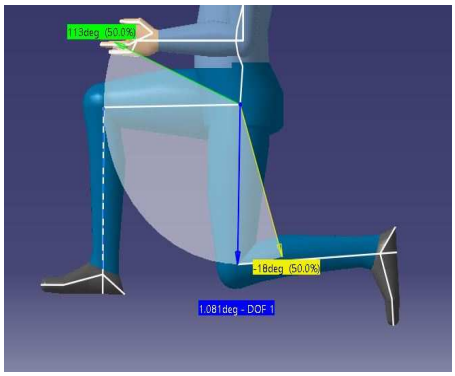

Figure 3: Limits of Angles of Hip Joint

This below diagram shows the representation of relation between the coordinates and the angles of the human leg. Here θ is angle along x-axis, β is angle along Y-axis, γ is angle along z-axis on the given representation.

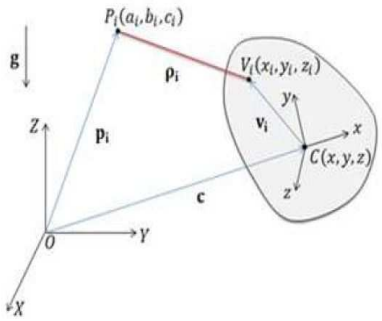

Figure 4: The Schematic Diagram for the position of the Square Plate with Respect to Origin

$$\rho_i = \| c + Q v_i - p_i \|$$

$$Q = \begin{bmatrix} \cos\beta\cos\gamma & -\cos\beta\sin\gamma & \sin\beta \\ \sin\theta\sin\beta\cos\gamma + \cos\theta\sin\gamma & -\sin\theta\sin\beta\sin\gamma + \cos\theta\cos\gamma & -\sin\theta\cos\beta \\ -\cos\theta\sin\beta\cos\gamma + \sin\theta\sin\gamma & \cos\theta\sin\beta\sin\gamma + \sin\theta\cos\gamma & \cos\theta\cos\beta \end{bmatrix}$$

Where

ρi = lengths of the cable.

Pi= Position vector of point Pi in relation to the fixed frame.

Vi= is the position vector of point Vi in relation to the moving frame.

and c is a constant considered as zero.

The above equation specifies the relation between the rotation and the movement of the leg without affecting the human body to strain. The forces that are considered for the implementation of analysis on the bracket as well as on the string are self-weight of the leg minimum force required by the string to lift the patient's leg is 50 N and self-weight.

4. ANALYSIS AND RESULTS

In this section we are trying to evaluate the analysis of the model using Adams software and following results have been obtained through the graphs

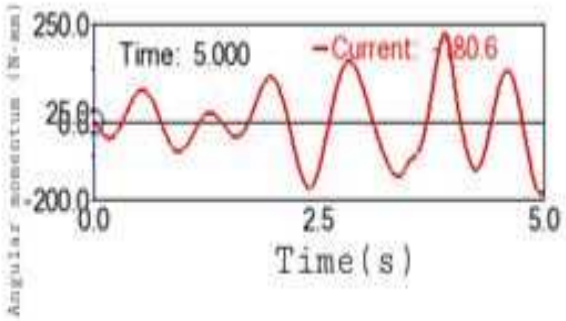

Figure 5: Angular Momentum

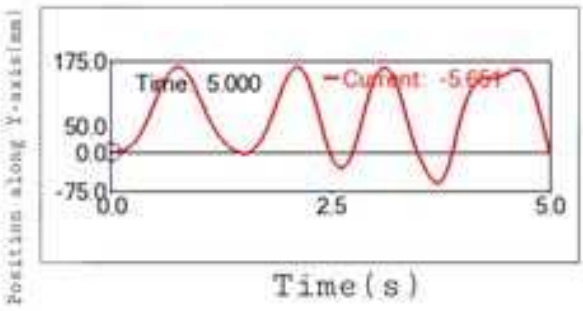

Figure 6: Position along y Axis

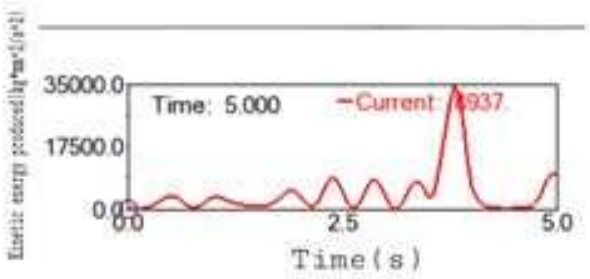

Figure 7: Kinetic Energy Produced

The Cable that attaches the winch with the bracket is also the one to be tested or analyzed so that the wire does not break.

4.1 Cable Analysis:

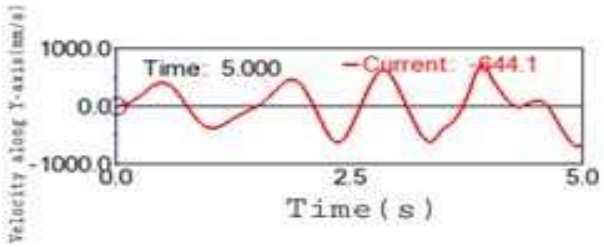

Figure 8: Velocity Produced by the Motor in y Direction

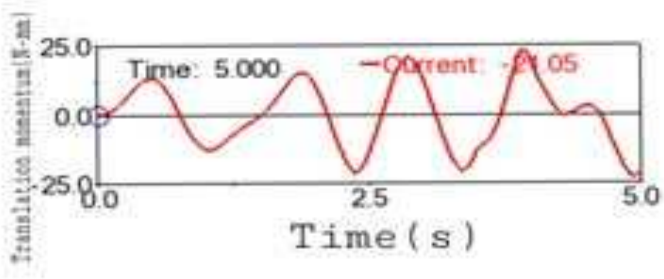

Figure 9: Translational Momentum of the Human Leg

Figure 10: The Final Design of the Cad Model of the Cable Driven Parallel Manipulator

4.2 Results

The above analysis results show that the minimum amount of Stress that the string can be able to bear with the above loading conditions specified as above. As we can see that the analysis of above components The maximum Deformation of the square Bracket plate is very negligible that is 0.23*10^-6 mm. The minimum deformation of the Square bracket plate is zero mm. From these inferences we can be sure that the component does not break or crack under the tensile forces of the string as well as the weight of the leg and pulley. The Tension analysis of the string component shows a maximum stress developed at the support. That is the value of the stress developed is 40.638 N/mm^2. Minimum Stress developed at the free end of the string is 40.027 N/mm^2. From the above analysis we can be sure and safe enough that the system works perfectly according to theoretical approach and analysis also shows allowable stresses.

5. CONCLUSIONS

In this paper applications are displayed of a link based mostly framework as supporting and managing movement gadgets. Specifically, it's been incontestable that a reconfigurable four-link based mostly controller will be used as a movement facilitate convenience for managing developments of the higher and lower appendages. In such applications, it's of polar significance that the framework, set up and mimic acceptable ways in which. The employment of programming for copy of multibody frameworks allowable the confirmation of projected structure encouraging model development. Graphical reenactments and wildcat check had been brought through demonstrating the legitimacy of the projected link driven parallel controller which will replicate the lower appendage developments. Therefore, this convenience has the basic conditions to be connected in exercise based mostly recovery centers, doctor's facilities and residential, encouraging and advancing the healer work, and to boot offer information concerning patient advancement.

REFERENCES

1. *A. Pennycott, D. Wyss, H. Vallery, V. K-Marganka, R. Riener, Towards more effective robotic gait training for stroke rehabilitation: a review, in: Journal of NeuroEngineering and Rehabilitation, 9:65 (2012).*
2. *N. Takeuchi, S-I. Izumi, Rehabilitation with Poststroke Motor Recovery: A Review with a Focus on Neural Plasticity, in: Stroke Research and Treatment (2013).*
3. *R. Colombo, I. Sterpi, A. Mazzone, C. Delconte, F. Pisano, taking a Lesson from Patients' Recovery Strategies to Optimize Training During Robot-Aided Rehabilitation, in: IEEE Transactions on Meural Systems and Rehabilitation Engineering, Vol. 20, nº 3 (2012).*
4. *A. N. Kuznetsov, N. V. Rybalko, V. D. Daminov, A. R. Luft, Early Poststroke Rehabilitation Using a Robotic Tilt-Table Stepper ans Functional Electrical Stimulation, in: Stroke Research and Treatment (2013).*
5. *I. Díaz, J. J. Gil, E. Sánchez, Lower-Limb Robotic Rehabilitation: Literature Review and Challenges, in: Journal of Robotics (2011).*
6. *R. S. Gonçalves; J. C. M. Carvalho, Robot Modeling for Physical Rehabilitation in: Service Robots and Robotics Design and Application. An imprint of IGI Global, pp. 154-175 (2012).*
7. *Sivakumar, S., Ranjithkumar, N., & Ragunathan, S. (2013). Design and development of down draft wood gasifier. International Journal of Mechanical Engineering, 2(2), 1-10.*
8. *R. Rupp, H. Plewa, E. P. Hofer, M. Knestel, Motion Therapy@Home – a robotic device for automated locomotion therapy at home. In IEEE 11th Int. Conf. on Rehabilitation Robotics, Kyoto, Japan, (2009).*

9. G. Cannella, E. Ottaviano, G. Castelli, A cable-based system for aiding elderly people in sit to stand transfer, in The Int. Symp. on Multibody Systems and Mechatronics, pp. 8-12, (2008).

10. M. Hiller, K. Hirsch, T. Bruckmann, T. Brandt, D. Schramm.

11. Kumar, G. N. S. and A. Srinath. 2018. "An Ergonomical conditions of Pedestrians on Accelerating Moving Walkway: A People Mover System." International Journal of Mechanical and Production Engineering Research and Development 8 (Special Issue 7): 1376-1381. www.scopus.com.

12. Kumar, Gurram Narendra Santosh, and A. Srinath. "Exploration of Accelerating Moving Walkway for Futuristic Transport System in Congested and Traffical Areas." (2018): 616-624.

13. Aru, S., Jadhav, P., Gajabhiye, S., Jadhav, V., & Angane, P. (2014). Design and Analysis of Centrally Suspended Cage-Less Differential. International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), 4(4), 49-60.

14. Rama Chandra Manohar, K., S. Upendar, V. Durgesh, B. Sandeep, K. S. K. Mallik, G. N. S. Kumar, and S. H. Ahammad. 2018. "Modeling and Analysis of Kaplan Turbine Blade using CFD." International Journal of Engineering and Technology (UAE) 7 (3.12 Special Issue 12): 1086-1089. www.scopus.com.